DOCUMENT RESUME

ED 211 099 IR 009 927

AUTHOR Daly, D. W., Ed; Robertson, S. M., Ed.
TITLE Keller Plan in the Classroom.
INSTITUTION Scottish Council for Educational Technology, Glasgow.
REPORT NO ISBN-0-86011-015-X; SCET-OWP-4
PUB DATE 78
NOTE 60p.

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS Case Studies; Elementary Secondary Education; Foreign Countries; Higher Education; *Independent Study; Learning Motivation; Lecture Method; *Mastery Learning; *Pacing; Proctoring; *Science Instruction
IDENTIFIERS *Keller Plan; *Scotland

ABSTRACT

This guide for teachers considering using independent learning describes the Keller Plan and describes ways in which it has been adapted for use in a variety of school situations. A discussion of the Keller Plan and its original formulation is followed by six case studies written by teachers in schools and colleges describing their use of the Keller Plan. The first four case studies deal with the implementation of the Keller Plan in physics courses and the fifth in a chemistry course. Each describes how teachers introduced it into schools were timetabling and other constraints led to a number of modifications to the plan; the sixth study describes how the plan was introduced and organized in a Further Education College where the constraints were quite different. The last chapter comprises a report on a seminar organized by the Scottish Council for Educational Technology and attended by all of the teachers who had written the case studies. This seminar provided a forum for discussion of the case studies and generalizations about the Keller Plan in the classroom were made based on the experience of the participants. A list of 10 references is included. (CHC)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED211099

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☐ This document has been reproduced as received from the person or organization originating it.

☒ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.

KELLER PLAN IN THE CLASSROOM

edited by

D.W. Daly

and

S.M. Robertson

Occasional Working Paper 4

Scottish Council for
Educational Technology

IR009927

"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Richard N. Tucker

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

Contents

		Page
Introduction		3
Chapter 1	Keller Plan Stuart M. Robertson, B.Sc., M.Sc., M.Ed.	4
Chapter 2	Case Studies *Keller Plan in the Classroom* Ross Dawson, B.Sc., and Stuart M. Robertson, B.Sc., M.Sc., M.Ed.	9
	Report on the Implementation of Keller Plan Learning in S2 Physics Peter Bates, B.Sc.	14
	Medium Term Independent Learning in Physics David J. McCullough, B.Sc., D.A.S.E., M.Inst. P.	19
	A Keller Plan at Peebles High School H. C. Boag, B.Sc.	28
	Individualised Learning in Chemistry John Reid, B.Sc.	36
	PSI at Dumfries and Galloway College of Technology Alexander Logan, D.P.L.E.T.	39
Chapter 3	Seminar Report Dennis W. Daly, B.Sc., M.Sc.	46
Further Reading		58

The Scottish Council for Educational Technology was established in November 1975 as part of an overall plan to realign and expand the activities of the former Scottish Film Council to meet the needs of education and training in the 1970s.

One of the Council's stated objectives is

> To promote and encourage the understanding and application of educational technology in its widest sense throughout education formal and informal..., by means of
>
> (i) The establishment of links between individuals, institutions and authorities, both national and international, for the purpose of contributing to the development of communication in learning and training systems.
>
> (ii) The appropriate provision of information, advice and services designed to facilitate the most effective application, utilisation and management of educational technology.

The Council has recognised as an area of high priority, support for curriculum development and stemming from this recognition, has commissioned its fourth Working Paper—a teacher's view of Keller Plan in the classroom. In addition the Council proposes to run a series of workshops in Scotland which will introduce teachers to this new method of teaching and learning.

Introduction

This small booklet is intended to be a guide for teachers considering using independent learning. It takes one particular type of system which has been variously called Keller Plan, Personalised System of Instruction (PSI), Self-Paced Study or Student Paced Study System (SPSS) and shows how a variety of individuals have adapted it for use in a school situation.

The material which follows is written by teachers with other teachers in mind. It is written in simple language, avoiding excessive theory and avoiding also the temptation to idealise. The gist of the message is "This is what we did and this is what happened".

Few would deny that teaching by example is part of most teachers' credo albeit possibly an unvoiced one. For this reason we have not hesitated to include material from those who have tried to use Keller Plan and failed. An analysis of their efforts may well help other teachers to avoid the many pitfalls in the path.

The booklet is divided into three chapters. In Chapter 1, Stuart Robertson gives details of the background to the booklet and describes the historical background to Keller Plan and Keller's original formulation of the Plan.

Chapter 2 consists of a number of short papers written by teachers in schools and colleges describing their use of Keller Plan.

Chapter 3 consists of a report written by Dennis Daly on a seminar organised by the Scottish Council for Educational Technology and attended by all of the teachers who had written the case studies. The seminar participants had read the papers contained in Chapter 2 and the purpose of the seminar was to provide a forum for discussion of the different papers and to attempt to make some generalisations, based on the experience of the participants, about Keller Plan in the classroom.

References appear at the end of each paper where appropriate and a short list of further reading completes the booklet.

Chapter 1 Keller Plan

Stuart M. Robertson, B.Sc., M.Sc., M.Ed.
Principal Teacher of Physics,
St. Augustine's High School, Edinburgh

BACKGROUND TO THIS PUBLICATION

In September 1973 the Institute of Physics ran a course in the University of Surrey entitled "More Learning—Less Teaching". The aims of this course were based on the principle that instruction in schools and colleges should become more "personalised" i.e. students should be encouraged to learn for themselves, at their own pace. As a result of the course several Edinburgh teachers were introduced to the Keller Plan or PSI. Although it had been in use for some time in the United States and was beginning to find a place in the English University scene the Edinburgh teachers felt that Keller Plan had a role to play in Secondary Schools.

I first met the Keller Plan when my then Head of Department, Ross Dawson, one of the teacher participants in the Surrey course, brought back to the Physics Department in St. Augustine's the basic ideas behind Keller type courses. As a department we were all comparatively young but had come through training college with the idea that teaching was somehow intimately tied up with the notion of the performing teacher-back against the black-board, setting the pace and inspiring the class to fresh heights of enthusiasm by his sheer charisma. It was difficult to see ourselves in the new roles of organisers and tutors as required by the proposed new method. True, we could understand it working in universities but schools were subject to quite different constraints. Could Keller Plan be made to work in the school environment? This was the question we in the Physics Department of St. Augustine's High School set out to answer in the only way we knew how, by trying it.

I have elsewhere (1) documented the manner in which the system evolved as a response to feedback from the pupils and specific problems which arose during the formative period. Suffice it to say that now four years later we are convinced that in our particular school our particular way of operating the Keller Plan gives effective results. However, the question still stands in my mind: "Can Keller Plan be made to work in a variety of schools under a variety of different conditions?"

The inspiration for this publication has its roots partly in the desire to answer the above question by drawing on the experience of practitioners

and partly in the hope that the material contained within will inspire others to try PSI and so add to the available pool of knowledge.

HISTORICAL BACKGROUND TO KELLER PLAN

In 1962 Professor Fred Keller and three others were attempting to establish a Department of Psychology in the University of Brasilia. As Keller and his colleagues were given complete freedom of action, they decided to try out a new teaching method based on learning reinforcement theory. The method which evolved was tried out in a short laboratory course at Columbia University in 1963 and the basic procedures were employed the following year in a one-term introductory course at Brasilia. The new procedures were well received and the results were very satisfactory. In 1965 Keller and Professor J. G. Sherman began applying the method in Arizona State University with an increasing number of students each term. The popularity of the method gradually spread. In 1968 we read in Keller's original paper (2) of the methods being tried at Grinnell College (Iowa) and at Queen's College (New York). By 1971 several Universities such as the University of Texas and M.I.T. had been experimenting with Keller Plan courses and had published favourable results (3), (4).

In Britain Keller Plan teaching was pioneered at the University of Surrey by Professor Lewis Elton (5), (6) and the growth of its popularity in Higher Education has been well documented in a series of bulletins published by the Institute for Educational Technology, University of Surrey. However, to the author's knowledge very little work has been done on Keller Plan teaching in British schools, although work of a broadly similar nature was carried out by David Bosworth in Kibworth High School, Leicester (7). In 1967 Reid and Booth (8) began a series of experiments in Biology teaching using what they termed "independent learning" and in 1972 Eric Green published the results of experiments using individualised learning in Physics at Countesthorpe College, Leicester (9). Most other workers in the field are evolving systems which use independent learning as only part of their teaching strategy. Reid and Booth (10) have called these approaches short-term or medium-term independent learning as opposed to the Keller Plan which is long-term independent learning.

KELLER'S ORIGINAL FORMULATION

PSI has its roots in learning reinforcement theory whose basic law

Thorndike's "Law of Effect"—tells us that behaviour which is reinforced will tend to occur again. This relationship between behaviour and its consequences stresses the importance of active participation on the part of the student in a learning situation and highlights the ineffectiveness of a traditional lecture situation which all too often places the student in a passive spectator role.

Those familiar with Skinner's work on programmed instruction will notice many similarities between the latter and PSI—material is presented in small steps, the student responds, there is immediate feedback, the student progresses at his own rate, the programme leaves a permanent record and so can be improved, desired terminal behaviour is clearly specified and punishment is minimal.

Keller set out to evolve a system which placed the burden of learning firmly upon the shoulders of the learner and displaced the teacher from his traditional role. In his own words (11)

> In systems like these, and in the one I have centred on, the work of a teacher is at variance with that which has predominated in our time. His public appearance as classroom entertainer, expositor, critic and debater no longer seems important. His principal job... is truly the facilitation of learning in others.

The main idea in Keller's method is that the student should be freed from the traditional yoke of class-paced instruction and allowed to work at his own pace through a series of instructional units achieving mastery at each step. In an introduction to a psychology course written by Keller, the students read the following (12)

> This is a course through which you may move from start to finish, at your own pace. You will not be held back by other students or forced to go ahead until you are ready. At best you may meet all the course requirements in less than one semester; at worst you may not complete the job within that time. How fast you go is up to you.

There is of course more to Keller's approach than self-pacing. Keller's method involves dividing up the work which is to be taught into units, each containing a series of reading assignments and laboratory exercises to be carried out. The students proceed through the units at their own pace and it is up to them to decide how much of the reading they wish to do as homework.

On completion of a unit of work the student sits a unit test which is

marked in the student's presence by a student proctor. If the results of the test convince the proctor that the student has mastered the unit, then the student is free to continue to the next unit. The proctors are undergraduate students who are chosen for their previous mastery of the course and who play a large part in the day-to-day organisation of the method. In addition to the proctors, there are graduate laboratory assistants and instructors.

Keller alters the normal role played by lectures and demonstrations. These become vehicles of motivation rather than sources of critical information. No examinations are based upon lecture material and attendance at lectures is not compulsory. Lectures become rewards for students who have reached a certain point in the work. This new emphasis on the lecture as a "special show" is actively fostered by Keller.

As a result of the non-compulsory nature of lectures and the unit structure of the course, a great stress is placed upon the written word in teacher-student communication. Finally, all the students sit a final examination at the end of term. The examination comes at the same time for all students and covers the entire term's work. The questions are mainly from the unit tests and the examination contributes 25% to the course grade. The remaining 75% is based upon the number of units covered and the laboratory work successfully done.

To summarise then, the main points in the Keller method, in Keller's own words, are:

1. Self-pacing: the go-at-your-own-pace feature, which permits a student to move through the course at a speed commensurate with his ability and other demands upon his time.
2. Mastery: the unit-perfection requirement for advance, which lets the student go ahead to new material only after demonstrating mastery of that which preceded.
3. Lectures as motivation: the use of lectures and demonstrations as vehicles of motivation, rather than sources of critical information.
4. Stress upon the written word: the related stress upon the written word in teacher-student communication.
5. Use of proctors: the use of proctors, which permits repeated testing, immediate scoring, almost unavoidable tutoring, and a marked enhancement of the personal-social aspect of the educational process.

REFERENCES

(1) Robertson, Stuart M. *Teaching Physics by the Keller Plan in a Secondary School* (1976). Unpublished M.Ed. Thesis, University of Edinburgh.

(2) Keller, Fred S. "*Good-bye Teacher...*". Journal of Applied Behavioural Analysis, 1, 1968, pp. 79–89.

(3) Koen, Billy V. *Self-Paced Instruction in Engineering*. IEEE Transactions in Education, February 1971.

(4) Green, Ben A. Jr. *Physics Teaching by the Keller Plan at M.I.T.* American Journal of Psychology 39, 1971, pp. 764–775.

(5) Sherwood, M. *Educational Innovators*. New Scientist, June 7th 1973.

(6) Elton, L. R. B., Boud, D. J., Nuttall, J., Stace, B. S. *Teach Yourself Paradigm—the Keller Plan*. Chemistry in Britain 9, 4, p. 164.

(7) Bosworth, D. P. *Teaching Science Individually through Programmes*. School Science Review 48, 1967, p. 702.

(8) Reid, D. J. and Booth, P. *Independent Learning in Biology*. School Science Review 52, 1971, p. 50.

(9) Green, E. L. *Individualised Learning in Physics*. School Science Review 54, 1972, p. 260.

(10) Reid, D. J. and Booth, P. *Independent Learning in Science—a Review of Present Progress*. School Science Review 55, 1974, p. 435.

(11) Keller, Fred S. Op. cit.

(12) Keller, Fred S. Op. cit.

Chapter 2 Case Studies

KELLER PLAN IN THE CLASSROOM

Introduction into Physics Department, St. Augustine's High School, Edinburgh

Ross Dawson, B.Sc., Adviser in Science, Lothian Region and
Stuart M. Robertson, B.Sc., M.Sc., M.Ed.,
Principal Teacher of Physics,
St. Augustine's High School, Edinburgh

Introduction

We are often asked why we stopped using "traditional teaching" and began using a type of independent learning. Although it is often difficult in retrospect to isolate the factors responsible for innovation, one answer might be that the scene was suitably set and the correct stimulus happened to come along. In 1973 the Physics Department was staffed by teachers young enough to feel doubts about the efficacy of lock-step lecture type teaching and energetic enough to do something about these doubts when a suitable stimulus came along. The stimulus was hearing about a learning system called Keller Plan which allowed the students to work at their own pace independently of the teacher and to develop regular and organised study habits.

We first heard about Keller Plan teaching via an in-service training course organised by the Institute of Physics in Guildford, in 1973. Although to our knowledge the method was only in use in tertiary education, we saw no reason why it could not be adapted for school use; so in the Spring of 1974, we began writing our first units and at the beginning of the 1974/75 School Session, with great trepidation, we stopped all traditional S3 'O' Grade Physics teaching and began our first Keller Course. The year which followed was one of frantic unit writing as we tried our best to keep ahead of the fastest pupil. The results, after a year's work, were promising enough to encourage us to extend the method into S4 and S5 and now 3 years and 52 units later, the full SCE 'O' and 'H' grade courses are taught exclusively by this method. As well as the improvements which have occurred in discipline, interest and pupil attitudes the actual attainment of the pupils in SCE exams has been encouraging enough for us to continue our development of the system.

The Units

The format used follows the style suggested by Keller and consist f four definite sections. For ease of identification in our system each is colour coded. The sections comprise:

(a) *Introduction* This is a brief over-view putting the unit into the context of the course as a whole.

(b) *Objectives* These list specifically what the pupil should be able to do after completing the unit. Although this is meant to be read before starting the unit it also doubles as a useful check-list on completion of the unit.

(c) *Procedure* A step-by-step account of what the pupil has to do to achieve the objectives. We have tried to make this as varied as possible. Thus, apart from being directed to read some passage from the text-book, the pupil might well be asked to view a video tape, look at a film loop, carry out an experiment, complete a summary sheet or attempt certain tutorial examples. We have tended to depart slightly from the American viewpoint that lectures should play a non-essential motivating role. Where we felt that the work was particularly difficult and required special explanation we included attendance at a lecture in the procedure. This programme for learning may well include optional sections not covered by the specific objectives.

(d) *Unit Test* This test covers all the stated objectives and is taken by the pupil when he and his teachers consider he is adequately prepared. Satisfactory mastery of the work of the unit as indicated by this test allows the pupil to proceed to the next unit. Here we have departed from Keller's requirement of near 100% mastery and rely instead on the teacher's estimate of what can reasonably be expected of that particular pupil. This removes the requirement of formal parallel tests but now the teacher must constantly exercise his professional skill in organising the necessary remedial work in the event of unsatisfactory performance in the unit test. We have not limited the unit tests to objective type questions as we feel the pupil needs practice of both objective and open-ended questions.

The Method in Use

At present the number of pupils studying physics in the school is as follows:

S3—75 S4—90 S5—40

So, some 200 pupils are at present using our Keller-type system. The timetable is so organised that the whole of each year group takes physics at the same time.

When pupils arrive in the Physics Department they first report to a member of staff for registration and announcements and they are then generally free to work in the room of their choice. This allows them to choose which member of staff they want to help them although if one particular member of staff is occupied they will seek out someone else.

Full use is made of our lab technicians in operating the system. A small counter is set up, manned by a technician, and here the pupil can sign out text-books or apparatus as well as receive further units on presenting the technician with a properly signed "completion slip". These slips are the proof that the pupil has completed the work of the unit and has duly passed the unit test. The slips are signed by a member of staff at various points in the procedure: attendance at a lecture, completion of tutorial examples, and passing the unit test. Once the slips are returned to the technician the date of completion is entered from the slip on to a master chart which allows us at a glance to monitor overall progress. In addition, each member of staff keeps a loose-leaf folder containing the individual records for each member of his registration group. It is the responsibility of the teacher to update his record every week from the master chart so that at any time we can present a very detailed account of the progress of any pupil. The technician also collects "feedback sheets". These are an assessment by the pupils of the interest and level of difficulty contained in the unit as well as a chance for him to make any comment he may think relevant. These sheets are of course anonymous and give us continuous feedback on the units, sometimes resulting in major changes and rewrites.

Early Results

When we first introduced the S3 pupils to Keller Plan teaching it was apparent that the majority did not enjoy the responsibility of pacing themselves. We had worried about this from the start and when we started receiving feedback from the pupils indicating a desire for some sort of pacing guideline, we introduced a time schedule containing about two target dates a term and the corresponding units the pupils ought to have reached working at what we considered to be the slowest allowable rate. This solved, to our satisfaction, the problem of the pupils' inability to pace themselves within an entirely free system. Prior to the introduction of the time schedule the setting of a term exam, demanded by the school system, had caused us many worries. With each pupil working at his own pace

how do you set one exam? Various complicated schemes had been mooted but the introduction of target dates resulted in a simple solution. The exam was set to cover work up to the last target date with the fastest pupils having the bonus of wider choice.

It would be a deception to claim that every pupil has responded well to this method. Inevitably we identified a small group which was not managing to meet the slowest pace. As time went on these pupils fell further and further behind and conscience prevented us from commenting "they are just working at their own rate" for it became obvious that these pupils were becoming more and more disillusioned with their ability to cope. Our solution was to form what we termed a "catch-up group" which was assigned to one member of staff for intensive tutoring until they were up to schedule. They were then returned to the Keller system. These pupils were not recorded as having completed the unit until they had successfully taken the unit test. As time went on, the size of this group diminished and its composition was never static. Perhaps some of its members were just slow in adapting to the new system.

Although the existence of this catch-up group and the Time Schedule make nonsense of any claim that ours is a totally self-paced system, we firmly believe that any attempt to operate Keller Plan teaching in schools will necessitate some similar strategy; otherwise we will be faced with the high drop-out rate reported in some of the American literature.

Pupil Reactions

When we introduced the system we were well aware of the many problems involved in assessing the effectiveness of an innovation in terms of pupil achievement. The number and composition of the pupils varies each year making year by year comparison difficult, and the problems involved in accurately setting up comparable control and experimental groups both from the theoretical point of view and the staffing situations were so great that we decided that in terms of exam results if we as teachers could detect no deterioration we would be satisfied. So far we are pleased to report exam scores have been good enough to encourage us to continue although we would not claim a significant improvement due to Keller Plan.

However, there have been marked improvements in other spheres. Discipline problems have disappeared. Teacher-pupil relationship has improved due to much greater contact. Pupils now make much better use of text-books and will sit working even when a member of staff is absent.

Pupils often spontaneously form small discussion groups to debate a problem before calling in the teacher to arbitrate. Pupils' practical ability and confidence in handling apparatus has improved markedly due to increased time spent in practical work. This is by no means an exhaustive list of attitude improvements.

Let us finish by saying that the staff enjoy operating and developing the system and they feel intuitively that what they are now doing is much more what teaching is all about than the old "chalk and talk" method.

Ross Dawson and Stuart Robertson have given a very clear description of their Keller Plan system, which has been operating successfully in St. Augustine's High School for four years to the benefit of both staff and pupils.

In the next paper Peter Bates describes how he was impressed by the system at St. Augustine's and set out to try to implement Keller Plan at Firrhill High School.

A REPORT ON THE IMPLEMENTATION OF KELLER PLAN LEARNING IN S2 (SECOND YEAR) PHYSICS

Peter Bates, B.Sc.,
Principal Teacher of Physics,
Firrhill High School, Edinburgh

Introduction

It has been my view for some time, that one of the major challenges in teaching in a comprehensive school, is the wide variety of abilities and backgrounds presented to the teacher. Much emphasis has been placed on remedial teaching in the comprehensive school but much less emphasis has been placed on the needs of the very able pupils, and in particular on stretching the abilities of such pupils to their fullest extent.

There are various ways of coping with this situation, viz. various forms of setting or streaming, teaching at the average ability in a class, or some form of individualised learning. Since pupil abilities and backgrounds will always vary considerably within a given class, no matter how strictly streaming or setting is carried out, I felt that implementation of the Keller Plan might be the most suitable solution to the problem of teaching mixed ability classes.

My staff and I were very impressed by the system of teaching implemented by Ross Dawson and Stuart Robertson at St. Augustine's High School, both from their talks on the subject and from personal visits to St. Augustine's. We therefore wished to try to implement such a scheme in Firrhill High School, but we knew that there were major differences between the schools which could affect the success of implementation at Firrhill. The major differences were:

(i) At St. Augustine's, the scheme was implemented in Physics certificate classes which all come to the Science department at one time. In Firrhill, these classes all come at different times. This difference arises from the wide range of courses offered to pupils in S3 and S4 and the situation could not be altered without greatly affecting the course choice.

(ii) The Science department at Firrhill is scattered. Physics is taught in two sections of the school separated by about 150 metres and the same number of steps.

(iii) We have been, and still are, short of technician and laboratory assistance—in particular, it was not possible to set aside a technician or attendant to help with one or more classes in the appropriate Science teaching area. This shortage of assistance is due in part to the separate locations of the sections of the school Science department and in part to the Regional Authority's limitations on staff replacement.

To summarise, the problems facing us were:

> Could such a PSI scheme operate in the single class situation? Could we cope with the shortage of technician or attendant help? What limitations were imposed by the geography of the Science department in terms of equipment and technician/attendant help?

To try to answer these questions, we set out to try a PSI scheme for a limited period in classes where a lack of success would not affect the pupils in a disastrous way. We therefore elected to try the scheme in Physics classes in S2 for these and the following reasons: such a scheme had not to our knowledge been tried with S2 in Edinburgh; the S2 Physics scheme at Firrhill needed to be revised anyway; and it was our feeling that S2 was one area where able pupils were not being stretched to their full potential.

Structure of S2 Science Teaching at Firrhill

A knowledge of the structure of S2 Science teaching in Firrhill High School is needed to put the rest of this paper in context. For all subjects, S2 is divided into three broad streams. At the time of the PSI scheme (Autumn 1976), these streams were based on ability in languages, English and Mathematics (this year the streaming is based on ability in all subjects). The two upper streams (2A and 2B) appeared for Science for two double periods per week, the lower stream (2C) appeared for three double periods per week. Each stream appeared at different times and contained approximately six classes.

In S2, Science is taught as three separate subjects, i.e. Physics, Chemistry, and Biology. In 1976–77 the teaching was done on a rotational basis, each class being taught one of the sciences for six weeks and then changing teacher and subject for the next six weeks, followed by the third subject with a third teacher for the following six weeks. This had the result in practice that at a particular time in the week, two or possibly three S2 classes were being taught Physics.

Implementation of Keller Plan Teaching

A PSI scheme was devised by several teachers in the Physics department. The scheme included some topics which had not previously been taught to S2 and it was prepared over a period of two months. It was used with four classes in each of the 2A and 2B streams, leaving two classes in each stream to be taught the same material by more formal methods.

Since the six classes in a stream were of a similar ability range, it was felt that a valid comparison could be made between PSI and more formal methods—each class sat the same test at the end of the six week period.

The results of this experiment were mixed. The majority of pupils seemed to be keen to work using this method but encountered several difficulties. Many of them found difficulty in following the instruction sheets due to the sheets having a poor layout, being badly expressed and using English which was too difficult for them. Some of the pupils did not have the maturity or common sense to cope with relatively trivial problems by themselves.

There were also difficulties over shortages of equipment and textbooks. In a scheme lasting only six weeks the pupils did not really separate themselves out and there was a tendency for them all to be doing a given experiment at the same time or to require a given book at the same time. We tried to overcome the lack of assistance in supplying equipment by positioning experiments in a particular place in a particular room, but at times this led to thirty five out of forty pupils being in one room at a time.

Pupil performance in the class test at the end of the six-week period seemed to be little affected by the method of teaching. An analysis of the marks gained in the test by the Keller and the non-Keller groups in the 2A and 2B streams showed that there was no significant difference in performance between the two groups.

The particular advantages which we found in the scheme were:

1. Able pupils worked very hard and mastered the objectives well.
2. Teachers were able to diagnose able and weak pupils very quickly.
3. Individual problems of pupils were readily solved.
4. Staff gained a great deal of experience in implementing such a scheme.

The problems which we encountered were:

1. The instruction sheets were prepared quickly and were not very good, although able pupils were able to cope by using initiative and common sense.

2. Some experiments were not sufficiently foolproof in that pupils found difficulty in making them produce the results intended. This decreased their confidence in the scheme.
3. Because of the short nature of the course and apparatus limitations, many pupils bunched around a few pieces of apparatus.
4. There was no means of establishing a catch-up group for less able or lazier pupils because of the short duration of the scheme and the limited number (2 or 3) of members of staff available at the same time.
5. The less able pupils were not sufficiently mature to be left to work for themselves and had difficulty in following instructions.
6. There was a shortage of suitable textbooks.
7. The lack of suitable assistance from technicians or laboratory attendants placed an additional burden on teaching staff.

We decided not to pursue this scheme because of the problems just described, but we have learned some guidelines for future attempts at PSI schemes. Pupil reaction varied, but some able pupils were put off Physics by the scheme and in particular, by the poor instruction sheets.

Our Future Guidelines at Firrhill

I am not convinced that a Keller Plan system can be implemented at Firrhill because of a number of different constraints. However, I think that there are many "half-way houses" between formal teaching and a full Keller Plan type of instruction and these can be approached gradually. Our guidelines for future attempts at PSI are:

1. Have instruction or worksheets which have already been tried successfully with classes.
2. Approach the scheme without haste, planning well in advance and pre-testing as much material as possible with formally taught classes.
3. Prepare in advance and pre-test lists of the course objectives for pupils and teachers.
4. Prepare in advance and pre-test graded problem sheets and diagnostic tests.
5. Pre-test all experiments to be used.

At the present time we are working on the above guidelines for O and H grade classes. Also one of the staff has successfully implemented a full Keller-type system for a ten-week course in electronics (part of a CSE course in General Science).

I see the future of PSI for Physics teaching at Firrhill as progressing firstly at H grade where pupils can be trusted (hopefully!) to obtain and return all apparatus themselves, and where shortcomings can be overcome by initiative and common sense. At present, some time for teaching in a formal way will be retained but tutorial and experimental work can be done independently—possibly using a core and options technique. At the moment we are pre-testing new units with H grade classes in the manner outlined above.

As an aid to discussion, I list some of the general advantages and disadvantages of Keller Plan which we have noted.

Advantages

1. Pupils learn for themselves—fostering self-discipline and maturity.
2. The personality and capabilities of the teacher do not have such a marked effect on pupils' progress.
3. Pupils are aware of objectives and of their own progress in mastering objectives.
4. Pupil absence is not so catastrophic.
5. The pace of the course is adjusted to individual pupils' needs.
6. Teachers are more aware of the progress of individuals.

Disadvantages

1. Efficient use of teaching and technical staff demands several classes coming at one time—imposing constraints on rooms and timetables.
2. For successful operation, all rooms and stores in use at one time should be adjacent to each other.
3. Class discussion engendered by the teacher tends to be lacking; also, a teacher in a formal situation can do much to communicate enthusiasm for a subject.
4. Pupils must have a certain amount of self-reliance and maturity to operate the scheme successfully.
5. If used exclusively, this is a single approach to learning—some pupils may benefit from a varied approach.

Peter Bates ran into problems in his attempt to implement Keller Plan. Some such problems may be peculiar to a particular school but some of them can be overcome by careful planning and a co-operative effort, as is illustrated in this next paper by David McCullough.

MEDIUM TERM INDEPENDENT LEARNING IN PHYSICS

David J. McCullough, B.Sc., D.A.S.E., M.Inst.P.,
Head of Physics Department,
Knockbreda High School,Belfast

Summary

In this case study a workshop group based at Queen's University Teachers' Centre, Belfast, set out to produce and use independent learning materials. These were to be used by pupils in six schools leading to the Northern Ireland General Certificate of Education 'O' level examination in physics. The study deals with: the working of the group; the nature of the learning materials; the use of these materials in schools; recording of progress; evaluation; and an account of difficulties encountered in the practical operation of the project.

Some evidence is presented on the success of the project to date although at the time of writing, the pupils have not taken the N.I.G.C.E. 'O' level examination.

The Workshop Group

In the Spring Term of 1975 a group of teachers met at Queen's University Teachers' Centre to discuss the possibilities of applying independent learning methods to the 'O' level Physics course. Existing teaching methods were thought to be unsatisfactory and it was felt that more emphasis should be placed on the pupils' learning than on 'teaching'. Dictation of notes was thought to be time-consuming, reducing the time available for enrichment material on the fringes of the syllabus.

Following this meeting, and other informal discussions, the author obtained secondment to the Teachers' Centre as assistant organiser for one day per week. During this first year a series of fortnightly workshop sessions was held at which discussion of the content, format, aims and objectives of the pupils' work units took place. A number of such units were written and tried out in the classroom, the teachers reporting back to the workshop on progress made and difficulties encountered.

During that year a proposal was placed before the Northern Ireland Schools' Curriculum Committee that they adopt the project and give financial assistance. The proposal was accepted and, as co-ordinator, the author was asked to continue for a further two years on secondment,

during formal trials of the materials. The Teachers' Centre agreed to provide typing assistance and duplicating facilities.

Six schools in the Belfast area agreed to participate in the trials. The selection of schools was such that a representative sample of the population would follow an independent learning approach towards the N.I.G.C.E. 'O' level Physics exam in June 1978. The trials would involve about 400 pupils, 10% of those normally entered for Physics each year. To facilitate writing and production of the units the order in which they would be used was agreed by the teachers concerned.

The Nature of the Learning Materials

The general aims were:

(a) to enable each pupil to work at his/her own pace;

(b) to enable each pupil to acquire skills in the use of resources;

(c) to reduce the need for pupils to make long, time-consuming notes;

(d) to enable each pupil to obtain more individual attention from the teacher.

The structure of each unit was to be as follows:

1. Brief introduction, including reference to syllabus, textbooks and other units.
2. Pre-requisite knowledge, including mathematics.
3. Pre-test to assess this knowledge.
4. Answers to pre-test and comments.
5. Remedial materials if required.
6. List of objectives to tell pupils what they should be able to do on completing the unit.
7. Main material which may be experimental, reading, answering questions or using audio-visual aids.
8. Post-test to see if objectives have been achieved.
9. Remedial material for those who require it.
10. Optional mini-units.
11. Summary notes for revision.

Each unit would form the basis of the pupil's notes with additional notes being made on the back of each page or in a notebook with suitable references inserted.

The course would comprise twenty-six topic units plus three unifying themes on Energy, the Electromagnetic Spectrum and Kinetic Theory. Standard textbooks and apparatus would be used.

The Use of the Materials in Schools

Each unit would be issued complete to the pupils although with proper storage facilities, pages could be taken one by one by the pupils as required. The trials teachers would be given complete freedom to operate the system according to the constraints of each school situation. It was agreed that remedial material and optional extra work be made as interesting as possible; they were to be looked on more as a reward than as extra work. Progress records would be kept by each teacher. The teachers agreed that each of them would have to find his or her role in the classroom to maximise the effectiveness of the new method. In general they saw themselves acting as facilitators, trouble shooters, resources managers, observers and recorders of progress. They would try not to direct the pupils but would help them to re-direct themselves.

Recording of Progress

A master progress sheet for each class would give an overview of progress and if posted on the notice-board might be a motivating influence. There would be a record sheet for each pupil on which would be entered test scores, remedial work assigned, optional extra work and units completed. An open observation checklist would be used to record progress in skills and attitudes to work. A dossier of supplementary resources and audio-visual material would be compiled throughout the scheme for each school.

Pupils would be asked to complete a short attitude survey after each unit and a long one at the end of each term to assist in evaluation. These would also assist the teacher to modify the working methods if required. Pupils would be asked to respond anonymously so that a reasonably accurate picture of attitudes could be built up by computer analysis.

Pupil assessment was left to each teacher through homework, class tests, term tests, school examinations etc. The post-test for each unit would not only be a diagnostic tool for the pupil but it would also be used for evaluation of the learning materials.

Evaluation

In writing the units, objectives were stated, learning materials written to

help the pupils reach these objectives and post-tests set to see if the objectives had been achieved. Analysis of test responses by computer would indicate ineffective learning materials, faulty test items etc. It was expected that these analyses together with the observation check lists would indicate whether the pupils were learning and if they were not learning, the reason for this failure. The effectiveness and efficiency of the learning process would also be indicated.

A comparison of the performance of pupils following this scheme with that of pupils being taught by more traditional methods on the basis of final G.C.E. 'O' level exam results, might also give an indication of the effectiveness of the project.

Computer facilities were offered by the CAMOL project at the New University of Ulster, Coleraine, to analyse test responses and attitude survey responses for evaluation. The analysis would be given

(a) for the whole project

(b) for each school

(c) for each class

(d) for boys and girls separately.

The Practical Operation of the Project

What has been described so far has been achieved to a large extent and the success to date is due in no small measure to the co-operation of the staff at the Teachers' Centre. The pupils' units were produced without any delays being encountered by the trials teachers.

Much of the writing of units and tests was carried out by the teachers involved, outside the workshop situation. The workshop developed into an information exchange. Discussions took place on the operation of the project in the trials schools and on points of difficulty arising from the written material. Units produced were collected and feedback from the schools often collated at these sessions. This teamwork enhanced the progress of the project and few problems of communication were encountered. The six schools were within an eight-mile radius from the Teachers' Centre and this, together with the small number of teachers involved, ensured regular attendance at workshop sessions.

Pre-tests were written for the first few units only and very little remedial or optional material was produced. This was mainly due to lack of time available and in part to the lack of agreement as to what should be

included to meet the needs of pupils and resources available in the schools involved. With these exceptions the units were produced to the format as previously outlined. In addition a cover was designed for each block of units to make the presentation more attractive. Pupils preferred units reproduced by the "offset" process to those produced on the ink duplicator. For reasons of time it was not possible to incorporate different type faces although this would have been technically possible.

The fact that the units were tied to two textbooks did not prove to be any disadvantage. The limitations of one book were overcome by the other or by the intervention of the teacher.

(A new edition of one of the books will mean a complete revision of the references throughout the units since page numbers have changed and it is not convenient to refer to chapters alone.)

The possibility of having sets for a quarter of each class of four alternative textbooks was considered and if this were implemented, it might take into account differences in learning style amongst the pupils.

A few of the units were found to be applicable to C.S.E. work and were also suitable for use as revision prior to the topic being followed to 'A' level. Pupils who used the units in these contexts found them informative and enjoyable.

The possibility of publishing the work formally has been discussed and the general feeling was that such publication might well be the death of the project. The need to make such a publication widely acceptable would require a great deal of flexibility in the way of alternative experiments, variety of reference material and diversity of objectives to meet syllabus requirements. A publication of this type would be little more than a set of guide sheets to other resources. The present compromise of reasonably attractive "offset" production makes the units acceptable to the pupils while allowing changes and modifications to be made between reprints. Such changes may often require re-typing of one page only from a unit. A good set of master copies could also be used to make thermal stencils for ink processing or duplicate stencil plates for the "offset" process.

Most of the pupils in the trial group have adapted to independent learning quite well. There are a few who say the system is not working for them at all. Closer examination of the attitude surveys reveals that these same pupils do not want homework, tests, etc., i.e. these are the few who hope to pass 'O' level without any effort on their part. The majority find self-pacing an advantage provided they don't lag too far behind the main stream. If this happens they become discouraged and motivation drops.

Many of those who have been absent from school find it easy to catch up by planning to do book work at home and experimental work in class. Some prefer to work in groups of two or three, helping each other through difficult stages in the work.

In general the pupils can cope with independent learning and free access to equipment has been no problem either for the pupils or the teachers. Breakages and "disappearances" of apparatus have not increased and in many cases the pupils exhibit more care for the apparatus and for laboratory safety in general. Many of the pupils show great confidence in the use of equipment, having selected and assembled it themselves.

There are, however, a few general criticisms by those who seem to be progressing well. Firstly, a unit of more than about ten pages lowers the motivation of even the best pupils. The feeling seems to be "I'll never get through that!" To overcome this an attempt is being made to divide some of the longer units in two, although this will not be possible during the trials. Secondly, many of the pupils don't think they are learning anything. In spite of immediate feedback from post-tests, homework and other tests, many still need reassurance that they are doing well. This may be due to the absence of pressure on the whole class as would be evident with more traditional teaching methods. There doesn't seem to be an awareness amongst the pupils that by progressing at their own pace this pressure is unnecessary except when applied individually by the teacher to those who are not progressing as quickly as they might.

Thirdly, and finally, the variety which results from occasionally changing back to a traditional approach when appropriate, has proved to be an unforeseen bonus. On returning to independent learning after a few formal lessons, motivation seems to be very high. This may be the result of the reassurance that they can "put their feet on the bottom to test the depth" from time to time, and that the Physics Department has not gone completely mad in deciding not to "teach" them.

In conclusion a piece of "soft" rather than "hard" evidence as to the success of the project to date. The following attitude survey responses for a number of pupils should indicate to the reader, as it does to the trials teachers, the areas where improvements can be made and those where progress seems to be satisfactory.

INDEPENDENT LEARNING IN PHYSICS

ATTITUDE SURVEY FOR USE AT THE END OF EACH TERM

Put an X in the appropriate box to indicate your response to each statement. *BE HONEST*!

January 1977 / May 1977	Strongly agree	Agree	Disagree	Strongly disagree
1. I like the freedom to work at my own pace.	9 / 12	25 / 21	2 / 2	2 / 0
2. It is too easy *not* to work.	6 / 6	19 / 22	12 / 6	1 / 2
3. The teacher doesn't give enough help.	2 / 0	6 / 5	25 / 27	3 / 4
4. There is too much work to do.	1 / 0	4 / 4	25 / 31	7 / 1
5. It is good to have objectives specified.	6 / 4	29 / 25	2 / 7	0 / 0
6. I get more personal help from the teacher.	1 / 0	13 / 16	20 / 19	3 / 1
7. I would prefer a more conventional method of learning.	7 / 1	9 / 11	17 / 16	5 / 8
8. The work is too mathematical.	2 / 2	6 / 11	20 / 21	7 / 3
9. There is not enough experimental work.	0 / 1	4 / 3	28 / 28	6 / 4
10. There are too many tests.	1 / 2	14 / 7	16 / 27	6 / 0
11. There should be more marked homework.	6 / 4	10 / 13	17 / 11	5 / 8
12. There should be more discussion of difficult points in class.	13 / 5	18 / 23	7 / 7	0 / 0
13. I'm more interested in physics now than I was three months ago.	5 / 7	18 / 18	11 / 8	4 / 3

	Strongly agree	Agree	Disagree	Strongly disagree
14. The work is boring.	3 / 6	10 / 9	19 / 20	5 / 7
15. Experimental instructions should be more explicit.	6 / 3	22 / 18	9 / 14	1 / 0
16. I wish I hadn't chosen physics.	2 / 1	6 / 7	16 / 18	11 / 10
17. If absent, I can catch up easily.	2 / 4	25 / 26	7 / 5	3 / 1
18. I should be told exactly what to do each week.	3 / 2	11 / 7	23 / 24	1 / 3
19. The system is not working for me at all.	6 / 1	6 / 9	23 / 22	2 / 5
20. The post-tests don't cover the material.	1 / 0	8 / 4	22 / 30	7 / 2
21. There is too much reading involved.	0 / 3	7 / 7	25 / 25	5 / 2
22. The teacher should tell me where I ought to be in the unit.	3 / 1	17 / 18	15 / 13	2 / 4
23. There should be more material outside the syllabus.	4 / 3	15 / 16	14 / 15	4 / 1
24. More attempt should be made to relate physics to everyday life.	6 / 7	20 / 24	10 / 4	1 / 1
25. Teachers should be available after school to give further help on difficult parts of the course.	7 / 3	13 / 12	15 / 13	3 / 8
26. The units are badly made out.	0 / 0	6 / 11	28 / 24	3 / 1
27. I would prefer to write my own notes in a notebook.	8 / 4	12 / 8	14 / 19	3 / 6
28. It is difficult to revise from the units.	9 / 9	14 / 9	12 / 15	3 / 4
29. If the teacher was absent I couldn't cope.	0 / 0	7 / 9	26 / 23	4 / 5
30. I would prefer to be 'pushed' harder.	3 / 4	18 / 14	11 / 11	5 / 5

What I like about the system

What I dislike about the system

Suggestions for improvement

In the last paper David McCullough reported on a large scale co-operative project involving six schools for which a thorough evaluation programme has been devised. This next paper by H. C. Boag describes how he set up and attempted to evaluate a Keller Plan course in his school.

A KELLER PLAN AT PEEBLES HIGH SCHOOL

H. C. Boag, B.Sc.,
Principal Teacher of Physics,
Peebles High School

We changed to a Keller Plan to solve problems. Our previous traditional methods, the school structure and the attitudes of pupils had created problems to which we saw no solution within the traditional school framework. The purpose of this paper is to describe these problems and how we tried to overcome them.

Introduction

Peebles High School is a 1000-pupil comprehensive school which has 50–60 S3 (third year) physics pupils and 25–35 S5 pupils. Due to the nature of the timetable the three S3 sections and the two S5 sections do physics at different times. As allocation to a section is determined largely by the nature and number of subjects chosen, the different sections contain a wide range of ability. Here lies the source of the first problem which we encountered: how do we cope with mixed ability physics classes? I had previously tried within the 'lock-step' situation to encourage able pupils to do additional experiments. However, they were unhappy working on their own while I taught the rest of the class—they felt that they were missing something.

The nature of my present (1977–78) S5 sections is indicated below, illustrating the range of ability within the sections:

	S5 Section 1	*S5 Section 2*
Pupils from S4 with 'O' Grade mark A	7	12
Pupils from S4 with 'O' Grade mark B	4	1
Pupils from S4 with 'O' Grade mark C	1	3
Pupils from S5	1	2
Pupils repeating 'H' Grade (previous failure)	3	1
Pupils repeating 'H' Grade (upgrading previous pass)	3	0
Pupils taking 'O' Grade (crash course)	2	1

Pupils' expectations from a physics course will differ. Some pupils (or their parents) expect an 'A' pass at Higher Grade and in the Certificate of Sixth Year Studies to be used for entry to university. For others, an extra pass

at Higher Grade in any subject, taken over two years if necessary, will provide an entry to a desired job. Some want a pass at Ordinary Grade to enable them to enter an apprenticeship. Others have no expectations from the course and are present for a variety of reasons such as their parents' wishes or the requirements of the school curriculum. Thus our first problem was: how could we meet all these different demands, expectations and needs of pupils within the constraints of mixed ability classes?

Our second problem was concerned with providing remedial help for pupils who were experiencing difficulties in their course. Since 1973, my department has been using a set of tests as part of a continuous assessment programme. These tests identified for us areas of weakness and poor performance by a number of pupils.

Our problem was: how could we give help to a pupil who had failed a test? We could have given him extra work to do but we felt that this was an unrealistic proposition for a weak pupil who was already having difficulties. Individual remedial work could have been given but we found it extremely difficult to make arrangements for such work. Within school hours, timetable constraints made it difficult to arrange remedial work for pupils. Outwith school hours, a number of pupils occupied most of their free time with part-time jobs or rugby practice; for those pupils who were willing to work late, there were difficulties in finding transport home. In practice for most pupils failure to pass a test resulted in no action being taken. As parts of the course are sequential, we had the unsatisfactory situation that a pupil who did not understand Newton's Second Law could continue to work on energy.

Our third problem was concerned with pupil performance in the set of tests over a period of years. Between 1973 and 1976 there had been a progressive decline in pupil performance in these tests. Naturally this was a cause for concern: there had been no change in the staffing of the department or in the type of work: neither was there any evidence of a decline in the ability of the pupils.

To explain these results I postulated a "play now, work later" theory. The "play now, work later" pupil will put off study until a more convenient time. He is convinced that he can swot up the year's work during the Easter holidays. I felt that short term goals rather than a distant examination might provide such pupils with the necessary motivation to work regularly.

In our search for a solution to these problems, we felt that it was important that we should continue to use the set of tests as part of our

continuous assessment programme. There was agreement in the department that if a pupil should fail a test, he should repeat the part of the work relevant to that test. Naturally, this would mean that different pupils in a class would work at different speeds and they would be out of step with one another. To implement such a scheme, some form of individualised learning would be necessary. We felt that individualised learning might solve the problem of mixed ability classes, allowing able pupils to progress and less able pupils to obtain remedial help. Tests on a repeat-if-fail basis might provide the necessary short term objectives for pupils.

At the time my experience of individualised learning was based on the work of the Open University and of Keller. In April 1976, we started writing the units for our Keller Plan scheme and the Keller Plan course for S5 started in August 1976.

Writing the Keller Plan Units

Our units consist of about 3–4 weeks work for a pupil. Each unit contains a study guide, worksheets, experimental guides, problem sheets and tests. The study guide directs the pupils through the unit. It tells the pupil which parts of the textbook to read or summarize or learn; it instructs him to do certain experiments, the details of which can be found in an experimental guide or in a book; and it specifies the problems which the pupil must tackle and the order in which he should tackle them.

We found that the study guide, being the pupils' map through the course, was the most important and the most difficult part of a unit to write. We had to reconsider the content and objectives of the course and take decisions on the following questions. How much work should we include? Should we include items which are not included in the syllabus, even though they are good physics? How many problems should a pupil do and of what type? Where necessary, we wrote problem sheets which started with easy problems to build up pupils' confidence and then led on to more difficult problems.

To enable us to watch the pupils' progress, we required them to submit reports of experiments and some problems. These problems were usually taken from old Scottish Certificate of Education examination papers and were those for which the textbook did not provide answers. The answers to other problems were supplied on the problem sheet or in the textbook. The tests used were a mixture of objective and free-response questions Although these tests take longer to mark than purely objective tests, they reflect the nature of the SCE examinations.

The S5 course was divided into seven units:

Unit 1 Kinematics
Unit 2 Dynamics
Unit 3 Pressure and Kinetic Theory
Unit 4 Electrical Measurement
Unit 5 Alternating Current
Unit 6 Communications
Unit 7 Light and Spectra

The teaching of the last two units was reversed to accommodate some slow pupils and to reflect the fact that in the examination more marks were available for questions on Unit 7 than for those on Unit 6.

Any process of innovation requires extra work and Keller Plan is no exception. However, since innovators are also enthusiasts, such tasks may not be seen as work and it is difficult to remember how much time was spent in the preparation of the units. In April 1976 we set a target to have Units 1–4 completed by the end of June (we completed the first three!) and we planned to write Units 5–7 before the mid-October holiday. We plan to use the units for a three-year period, making minor revisions and correcting any major errors as necessary. This will enable us to prepare materials for S3 and S4. We started an S3 Keller Plan course in August 1977 and with some experience behind us, we have now broken the 'O' Grade physics course into 14 units and are working about two units ahead of the pupils.

The time allocated to each unit initially reflected the time we would have spent teaching that part of the course. Experience is suggesting to us that there are differences between our view and the pupils' views as to the time needed to complete a unit. To clarify the situation, we record when each pupil completes a unit and compare these dates with our original estimates.

Implementing a Keller Plan

Unlike other schools, our school has no central store for equipment and no laboratory assistant to set it out and take it in again. However, we have two physics laboratories with a preparation room between them and this allows us to have a free flow of equipment. We arranged for the two S5 sections to work at different times in the same laboratory so that we could concentrate S5 apparatus in the one place. As at least half of the pupils had been taught 'O' Grade physics in this laboratory they knew

where apparatus was kept and more importantly, what it looked like. We also relied on large notices on drawers and cupboards to indicate the location of apparatus.

Our successful use of this distribution system with S5 was misleading. We now find that we spend a lot of time in fetching and carrying apparatus for S3 pupils rather than teaching individuals with difficulties. In S3, the pupils do not know the appearance of such simple pieces of apparatus as a microphone nor do they know where apparatus is kept. To overcome this problem, we are trying to produce apparatus location lists complete with drawings where necessary.

We felt that pupils who submit problems and experimental reports for correction or tests for marking should—if possible—have them assessed immediately. This would provide positive reinforcement or enable corrections to be made quickly. Thus the teacher in a Keller Plan situation finds that he has to help with experiments, mark assignments and explain and expand the teaching materials. This appears to be—and sometimes is—a recipe for confusion. My own solution is to keep a well indexed loose-leaf file containing unit papers suitably annotated, solutions to submitted problems, unit tests and marking schemes. I also have a fold-out card at the back of the book on which I can indicate when a particular item has been submitted. To record the progress of the pupils we produced a pupil progress profile on which pupils can record when they have finished each part of the unit and the result of the unit test.

We were concerned that pupils would cheat—that they would copy the submitted work and the tests of other pupils. So far we have evidence of co-operation among pupils but we have no evidence of blatant cheating—even when tests are not administered to the whole class at the same time. I would like to think we have persuaded them that learning is a personal matter, not a fight between them and me.

The reaction of pupils to Keller Plan varied from enthusiasm to rejection, from constructive criticisms to platitudes which the pupils thought we would like to hear. Here are some comments from S5 in March 1977:

"A Keller Plan is better for enthusiastic people—you can work at your own pace and consequently don't get bored or left behind."

"Good idea but I don't like doing it myself."

"It does help if you want to go on to the Certificate of Sixth Year Studies or University. The advantage is that you have already learned to work on your own."

"More help is needed with experiments."

Evaluation

We attempted to evaluate the course by giving the same examination in January 1977 as was used in January 1976. By that time we expected pupils to have completed about 4 of the 7 units. The results are shown below:

	Mean
1976	60 out of 120
1977	66 out of 120

Given a sample of about 25 in each group the difference of six marks was not statistically significant when a Fisher's t-test was applied.

We then looked at the scores obtained in individual questions in the free response part of the paper. The mean values are shown below:

Question No.	*1976*	*1977*
1	4.5	6.1
2	6.9	7.9
3	5.0	7.4
4	4.6	5.8
5	3.6	4.0
6	3.8	5.5
7	3.6	3.5
8	4.7	4.7
9	5.6	5.2

(Maximum marks for each question is 10.)

A Fisher's t-test was applied to these scores but only in question 3 is the difference in scores statistically significant (at 1%). In answering questions 1–6 the 1977 group used knowledge acquired using Keller Plan, while questions 7–9 were based on material dealt with in the previous year when conventiontional teaching methods were used.

In July 1977 the results of the SCE examinations were published, not as a percentage, but in the form of "bands". The results are shown below:

	Mean band score	*% Passes of those sitting examination*	
1976	9.2	54	N = 24
1977	9.3	52	N = 25

The differences are clearly insignificant. As any difference could be attributed to a difference in the pupils' ability, I then compared the ability of the two groups using two measures:

1. The letter grade awarded for science at the end of S2. This is awarded on a purely statistical basis and can be taken as a rough measure of relative ability within the year group.
2. The band obtained in the SCE 'O' Grade examinations.

The tables below show the number of pupils obtaining a particular grade:

		1976 group	*1977 group*			*1976 group*	*1977 group*
S2	A	12	10	'O'	A	13	8
Science	B	8	8	Grade	B	5	9
marks	C+	1	1	band	C	4	4
	C–	0	1		Fail	0	4
	D	0	1				
	E	0	0				

I concluded that there was no evidence of a difference in the ability of the pupils in the two year groups. Having examined the performance and ability of the two groups, I would suggest that these results show that our pupils certainly did not suffer as a result of using Keller Plan. I am not disappointed by the results. Any improvement in performance I would expect to occur in those pupils who started the Keller Plan in S3.

To assess whether the rate of progress of pupils through the Keller Plan units matched up to our expectations, we noted when pupils finished each unit. We found that in general, pupils were working to schedule. However, this meant that for some pupils, Units 6 and 7 were done after the Easter holidays and to some extent were done by demonstration. We must revise our original schedule.

Conclusion

As indicated in the introduction, our Keller Plan course was started in order to solve three problems. We now feel that we can cope with mixed ability classes and with pupils who fail tests. Able pupils are able to proceed faster and can be given extra work to increase the depth and breadth of their knowledge. The third problem was concerned with a progressive decline in pupil performance in a set of tests over a period of years. For a number of reasons, the tests have now had to be changed so that it is impossible to determine whether the decline has been arrested. However, as indicated in the previous section, we are satisfied that our pupils are performing at least as well using Keller Plan as they had done under the traditional system.

It is difficult to assess objectively any changes in the attitudes of pupils but I think that there are some changes. I feel that pupils are now more willing to admit difficulties and to seek help. Perhaps this change in attitudes will be the real gain for the pupils from Keller Plan; if it is the only gain, our work will have been worthwhile.

We plan to expand the Keller Plan course in S5 and in future we hope to include extra optional units in astronomy, electronics and meteorology.

Some of the effects of our Keller Plan course may only show up in the longer term. When this Keller group reaches further education, we may then discover from their attitudes and performances if having been taught less, they have in fact learned more.

The foregoing papers have all dealt with the implementation of Keller Plan in physics courses. Chemistry teachers might be concerned that the hazardous nature of some chemicals and the difficulties in organising the distribution of chemicals and laboratory equipment would make individualised learning in chemistry impossible. That it is possible to implement such a scheme in chemistry is illustrated in the next paper by John Reid, who decided to start his scheme because a number of chemistry teachers had told him that it could not be done.

INDIVIDUALISED LEARNING IN CHEMISTRY

John Reid, B.Sc.,
Principal Teacher of Chemistry,
Holy Rood High School, Edinburgh

Introduction

Initially the concept of individualised learning in chemistry seemed rather daunting. I had seen the system begin in the Physics Department at Holy Rood High School and after some time I thought it could prove of use in the teaching of chemistry, by developing a sense of responsibility in the pupils and allowing them to work at their own rate. It seemed an ideal way of dealing with the ability range and catering to the different needs of each pupil.

The Units

At the outset the problems were enormous. The first major problem was the production of 'pupil units'. These took a considerable amount of time to write, type and duplicate. As the lay-out of the units was important, I found it necessary to type them out myself. I would estimate the production time for a unit to be between four and ten hours. The units varied in length and could take the pupils between four periods and sixteen periods (forty-minute periods) to complete. Having prepared one unit it was then necessary to have all the back-up material available. Using the Gratnell storage system, trays were made up for the unit. This involved designing the tray in such a way that it would hold ten sets of equipment and subdividing and labelling the tray so that it could be easily checked. The tray also contained a list of 'Other apparatus required'. This was for the use of the technicians, so that as a tray was required the technicians could refer to the list and ensure that everything was ready—lab packs, solutions, etc.

As soon as one unit had been written, it was necessary for me to begin another. This hectic pace continued for about eighteen months until the situation existing at present was reached. Most of the units for S3 and S4 are now prepared thanks to the co-operation of St. Augustine's High School, who also operate individualised learning in chemistry. By exchanging units between the two schools we have been able to adapt these units to our needs and hence cut out a considerable amount of work. Most of the equipment trays are now in operation and the units are being continually revised and up-dated.

Operational Experience

The main problem that I have experienced is lack of interest in the system by my staff. Two of them are Assistant Principal Teachers and as such are already heavily committed to their programmes, and the third is not impressed by individualised learning. I would reckon that for the system to work well all the staff would have to be one hundred per cent involved. The pupils are in favour of the system. It gives them a degree of independence, they respect the responsibility and they like working at their own rate.

As far as the hazardous nature of the materials that pupils have to work with is concerned, I can see no real danger as long as safe procedures are adopted. Certain things are mandatory in the laboratory; in addition to strict adherence to normal laboratory rules, safety glasses/goggles and eye-wash bottles must be present. Wherever a possible hazard exists, then a safety warning is written into the unit at the appropriate part. I have not yet had a pupil disregard such a warning. The pupils would seem to have a well-developed sense of responsibility in this area. The pupil/teacher ratio I do find a problem. A ratio of 20 pupils to one teacher is large for an individualised learning situation. It can mean that the teacher is in constant demand and consequently is not always aware of perhaps potentially dangerous procedures. For this reason I tend to use technicians as auxiliaries whenever possible.

Chemistry is a particularly 'messy' subject to teach by means of individualised learning simply because there are so many 'bits and pieces' required. Although I have a centralised storage system I find it necessary to stock all the chemistry laboratories with basic chemicals and basic chemistry laboratory equipment. By doing this I find it easier to operate the tray system as it eliminates the need for the transport of large quantities of the more innocuous materials. The only chemicals supplied from the store are the more exotic or hazardous ones, and such a procedure ensures that a check can be maintained on them (particularly magnesium).

Conclusions

I would suggest that the following are necessary prerequisites for any individualised learning in chemistry.

1. All laboratories must be adequately stocked with safety glasses, eye-wash bottles, etc.
2. All laboratories must have a basic stock of chemicals and apparatus.

3. All unit trays must be made up in such a way that they are easily checked and maintained. By including a list of other material required it would mean that unnecessary storage of unit material (solutions) was eliminated.
4. Wherever possible an attempt must be made to reduce the 20:1 pupil/teacher ratio by using technicians, laboratory assistants, students as auxiliaries.
5. All staff must be enthusiastic, co-operative and committed.

I have not yet operated individualised learning for a whole school session. There are two reasons for this, one being that the original units were too long and time-consuming. They contained a great deal of extra material, some of it outwith the syllabus and some of it repetitive. 'Traditional' teaching was adopted to complete the syllabus. This has now been remedied by cutting down the size of the units and removing the extraneous material.

The second reason is possibly more important as I feel that there is a tendency by the middle ability group of pupils to become bored with the units. I believe that it is necessary to vary the teaching methods to alleviate the boredom by using lectures, talk and chalk lessons and the 'normal traditional' type lesson where appropriate.

I envisage a system where any pupil having difficulty, or not working, would be assigned to a separate group. In this group the pupil would be taught and directed until he was prepared or ready to return to the individualised learning situation.

The preceding papers have described how teachers have introduced Keller Plan into schools where timetabling and other constraints have led to a number of modifications to the Plan. In the last case study, Alexander Logan describes how he introduced and organises a PSI scheme involving a number of different subjects in a Further Education College, where the constraints are quite different. A number of students who would have been unable to attend conventional college courses, have been attracted to the PSI scheme and in his paper Alexander Logan argues that PSI could play an important part in meeting the educational needs of society in the future.

PSI AT DUMFRIES AND GALLOWAY COLLEGE OF TECHNOLOGY

Alexander Logan, D.P.L.E.T.,
Senior Lecturer in Educational Technology,
Dumfries and Galloway College of Technology

Rationale

"It is the purpose of education to set men free." Carl Rogers (1) argues "that the aim of education is to assist students to take self-initiated action, to be responsible for each action, to become self-directive, to adapt flexibly to new situations, to co-operate effectively with others".

If Rogers' premise is accepted, one must seek a method of instruction which will achieve this educational goal. Individualised or personalised instruction by its nature emphasises the importance of student control in the learning situation and would seem to offer a means of approaching Rogers' goal. Five major characteristics of individualised learning have been listed by Gagné (2):

1. Beginning at an early age the student needs to learn the general principle that learning takes place as a result of his own intellectual activity.
2. Materials constituting stimuli for learning need to be designed for maximum accessibility and ease of use by the student.
3. Students should know the objectives of each unit.
4. The student needs immediate feedback relating to objectives.
5. Transfer of learning must be provided for... by discussion with a teacher and/or other students.

Empirical evidence on the practicability of this type of learning seems to be confirmed in research studies by McMichael and Corey (3) and by Born and Herbert (4) in their evaluation of the Keller Plan.

The Keller Plan or Personalised System of Instruction (PSI) has been described by Boud, Bridge and Willoughby (5) and it was with the above rationale and view of PSI that it was decided that an attempt should be made to introduce this form of individualised learning to Dumfries and Galloway College of Technology.

Introduction of the PSI Scheme

Once the educational aim and a method of achieving this aim had been

decided, the problem remained of how the scheme might be introduced. The prevailing organisational structure and the attitude of many members of staff made direct inception impossible. Many members of staff, although tentatively accepting the general idea of the scheme, believed that it would disrupt existing work in the College and place students at risk.

It was decided therefore that a new student body be recruited from people who could not attend conventional college courses—shift workers, housewives, business men and others. By using the PSI scheme, college facilities would be made available to those people. The scheme is in effect a learning by appointment scheme, as offered by many F.E. Colleges, but with two important additions: a tutoring facet and student interaction meetings. The interaction meetings are primarily social gatherings and are intended to compensate for the social rigours of private study. Their other purpose is to enable students to test their learning and help the organisers evaluate the effect of the scheme.

The underlying purpose of the new scheme was to prove that this method of learning was possible in the College. The fact that the College was able to increase its student body and serve a hitherto neglected part of the community without additional capital costs, gave the experiment credibility.

The PSI scheme was introduced in this way to the College in August 1975 and its main characteristics are as follows:

1. The student studies at times during the day or evening which suit him best.
2. The student also decides the day, the time and duration of each study period.
3. Each student is appointed to a tutor who decides on a suitable point of entry to a system and then monitors the progress of the student through the particular system.

French, German, Spanish, Italian and Modern Greek language systems are in operation and Accounting and Maths systems are being prepared.

The scheme is still in its infancy but initial reaction to it has been good and it is expected that it will continue to expand. How successful the PSI scheme will be in the College remains to be seen but the initial innovative exercise has been successful in that it is now official College policy that PSI be developed for use by members of the conventional student body. It seems to offer a solution to a problem which affected some students taking a group of subjects for the Scottish Certificate of Education. These

students sometimes were not able to study their own choice of a group of subjects because of the limited resources available. Two or more of their elected subjects might coincide on the College timetable. The introduction of PSI makes timetabling of individual students much more flexible.

PSI would also appear to offer a solution to a problem indigenous to rural areas. The problem is that because the rural community is relatively sparse, the demand for a course of study in a particular subject area does not often produce sufficient students to form a class. The expertise and facilities can be made available but economic viability in relation to class size prevents their use. If PSI systems were developed for those subjects for which there is a regular but limited demand, then the community would be better served. An expansion of student numbers would also allow lecturers to broaden the field of their activity and extend the scope of their work.

Detailed Description of the PSI Scheme

The scheme is organised by the College Educational Technologist in co-operation with the Head of Resources Centre. The Educational Technologist obtains tutors, assists in the development of learning systems and acts as a co-ordinator. The Head of Resources Centre provides learning facilities, operates the booking system and obtains commercial materials when appropriate. There are 19 learning units available in the Resources Centre and each student can book a unit for the day and time which is most convenient to him, by placing a magnetic strip bearing his name and subject on a magnetic booking chart. The Resources Centre is open for student use of the 19 units from 9 a.m. until 9 p.m. Each student is given the magnetic strip bearing his name and subject when he enrols for the scheme.

The College scheme has three facets—private study, tutorials and interaction sessions and each will now be considered briefly.

Private study

The student obtains appropriate materials (written, recordings on tape, tape-slide programmes or pre-recorded TV programmes) from the Resources Centre and uses them for private study, the materials being returned at the end of each study period. There are no restrictions on the duration or number of visits which a student can make during his course of study.

The difference between study using PSI and conventional study can be explained as follows:

In a conventional mode of instruction the student is exposed to materials by a teacher for a certain amount of time (the duration of a course); in this case, time is a pre-determined factor and student success depends upon how much he can absorb as the course proceeds. If the learning material were viewed as a merry-go-round at a funfair and the student were viewed as a watcher by the merry-go-round, the student could absorb as the material revolved before him.

In a PSI scheme, the learning material would be inert (the merry-go-round would be static) while the student (watcher) moved round the merry-go-round.

While the above analogy may be superficial in many ways, it can be used to illustrate to the PSI student how a greater degree of self-motivation is required of him. In the first case, movement and initiative lie primarily with the teacher while in the second case, the student supplies movement and decides his rate of progress.

I believe that it is important to distinguish for the prospective PSI student, the differences between conventional study and study using PSI because I feel that most prospective PSI students have a disability: they have not only learned certain subjects at school but they have learned to learn in a certain manner. To permit students to begin work in a PSI system without making an attempt to show them the important differences in methods, and the effects these differences can have on the learner, is to do a dis-service to both student and PSI scheme. Pursuing the point that PSI students must learn new techniques, most students are unused to the concept of complete mastery and this principle and its importance in relation to work using PSI must not merely be mentioned, but should be taught to the student.

Tutorials

Each student is appointed to a tutor. There are differences between tutoring and teaching. The concept of tutoring in the PSI scheme has the following characteristics:

(i) The tutor answers questions posed by the student. In effect initiative lies primarily with the student. This means that the student must pose specific questions to the tutor. Questions relating to a published text must include proper references (page, paragraph, sentence). It is thus

very important that when PSI materials are being prepared, consistency is maintained in terminology and care is taken when labelling and numbering the text.

(ii) The student can contact the tutor by making a recorded message, by written note or by special appointment. The Resources Centre staff 'liaise' between student and tutor. Some tutors are members of the College staff, others are not, but it has been possible to form suitable channels of communication with external tutors.

Most teachers seem able to adapt to a tutoring role but some do not. It may be that the 'laissez-faire' nature of the PSI scheme arouses feelings of disquiet in teachers since there is no direct control over students' work pace etc. This is not a criticism of such teachers since their anxious feeling is probably the result of wishing to become more closely involved with the students in order to help them in their studies.

It is important that the relationship between tutor and student should develop in such a way that formative evaluation of the learning materials can take place, and the student's co-operation should be sought by the tutor in an attempt to improve the materials. However, it must not be forgotten that the student's purpose in using the PSI system is to learn, and forms and questionnaires used for formative evaluation should be kept as brief and as simple as possible.

Interaction sessions

Keller's original formulation of his Plan does not include interaction sessions of the type offered in the College PSI scheme. There is, however, a similar underlying intent in both the interaction sessions and Keller's demonstrations and lectures, since in each case they are offered for motivational purposes.

Keller (6) states: "Relatively minor roles are given in our plan to the lecture and the demonstration. Their purpose is primarily motivational. They are not central to the educational process and they could be eliminated entirely without serious damage". The College interaction sessions, especially in Modern Language systems, are much more important than Keller's demonstrations or lectures since they seem to serve necessary functions particularly in helping students to test their learning by talking to other students and/or their tutor, and in providing feedback to tutors for possible revision of courses.

Interviews

In the section on private study, the importance of preparing a student for entry into a PSI system was emphasised. To help with this preparation, each prospective PSI student has two interviews, one with the Educational Technologist and one with his tutor. In the first interview, the Educational Technologist covers the points mentioned earlier in relation to private study and emphasises to the student the importance of checking performance levels and the dangers of procrastination. The other interview is given by his tutor and deals with the subject materials which are available to the student using a particular system.

It has been attempted to combine both interviews but it has been found that a single interview cannot adequately deal with both changes in study techniques and particular subject materials available to the student. Two separate interviews have been found to be a more suitable arrangement.

The Future

One of the problems of innovation is that a scheme can be implemented within an organisation but the organisation may only accommodate the innovation and not assimilate it. In other words, an innovation is superficially accepted but fundamentally things go on as before. Eventually the innovation falls into a state of discontinuance (7). Efforts have been made at Dumfries to avoid this by promoting a resource based concept of College organisation, which capitalises on existing departmental expertise. PSI becomes merely an extension of departmental activity. In this way PSI is not set up in opposition to traditional practice but complements it.

The future for PSI in F.E. Colleges should be seen in the light of the probability that in future, one of the major concerns of the education system will be to attract students, allowing them to study by whatever method suits them best. I believe that many people will no longer sublimate their life style and conform to study patterns which are convenient for an institution. Many people at present for one reason or another, are unable to attend conventional College classes and a PSI scheme may well meet their needs.

In schools, is it possible that PSI might alleviate truancy problems? Perhaps pupils could be persuaded to contract for a certain amount of work and then when they have fulfilled their contract, leave for the rest of the day. This may seem a very progressive idea but if the pupils are not attending anyway, it is surely an alternative worthy of consideration.

It is to be expected that there will be many comparative studies of PSI in relation to established methods and these are not to be condemned. A search for truth and facts is essential if progress is to be made. However, it would be a great pity if such comparisons gave rise to arguments which could divert attention from the important fact that there are a great number of people who are not being satisfactorily catered for by the education system at present.

The foregoing presents some provocative ideas and they must raise the question "Are present plans in some areas being made only on the basis of past experience and not in an effort to assess the demands society might put on the education system in the future?" Is not education a voyage of discovery and should we be so loth to predict and project? It is surely the job of management, whatever the field, to predict, initiate schemes and anticipate change.

References

(1) Rogers, Carl. *Client-Centered Therapy—Teaching Vantage Points for Study.* Edited by Hymen, R. T., J. P. Lippencott & Co., New York, 1968, p. 373.

(2) Gagné, R. *Quoted by John D'Arcy The Design of learning Systems* in *The Teacher as Manager.* Editor Taylor, G. National Council for Educational Technology, 1970, p. 25.

(3) McMichael, J. S. and Corey, J. R. *Contingency Management In an Introductory Psychology Course Produces Better Learning.* Journal of Applied Behaviour Analysis, 2, pp. 79–83, 1969.

(4) Born, David G. and Herbert, E. W. *A Further Study of Personalised Instruction for Students in Large University Classes.* The Journal of Experimental Education, Vol. 40, No. 1, 1971.

(5) Boud, D. J., Bridge, W. A., Willoughby, L. *PSI now—a review of progress and problems.* British Journal of Educational Technology, Vol. 6, No. 2, pp. 15–34, 1975.

(6) Keller, F. S. and Sherman, J. G. *The Keller Plan Handbook.* W. A. Benjamin Inc., London, 1974, Chapter 3, p. 19.

(7) Rogers, E. M. *Diffusion of Innovations.* Free Press of Glencoe, New York, 1962.

Chapter 3 Seminar Report

Dennis W. Daly, B.Sc., M.Sc.,
Adviser in Educational Technology,
Scottish Council for Educational Technology

INTRODUCTION

In January 1978, the Scottish Council for Educational Technology organised a seminar in Glasgow on the theme of Keller Plan in the classroom. The seminar was attended by the seven teachers who contributed the papers in the previous chapter of this booklet; by Dr. Evelyn Hay of the Department of Chemistry, Moray House College of Education, Edinburgh; by Dr. William Hogg of the Department of Natural Philosophy, University of Glasgow; and by Mr. Dennis Daly and Mr. Richard Tucker of S.C.E.T. The purpose of the seminar was to provide a forum for discussion of the different papers; to identify the problems which participants had encountered in the use of Keller Plan in the classroom; and to discuss the solutions which had been suggested to overcome these problems. It was hoped that some generalisations on Keller Plan in schools could be made, drawing on the experience of individual teachers.

BACKGROUND TO THE PAPERS

Each of the contributors of a paper gave a brief description of his use of the Keller Plan and his reasons for using the method. While these reasons varied from teacher to teacher, there were two reasons which were mentioned frequently.

Firstly, Keller Plan was seen by many as a method which might meet the demands, expectations and needs of pupils in mixed ability classes more effectively than traditional teaching. In some cases, there was no attempt to use the Keller Plan units across the whole ability range but there was still considerable variation in pupil ability in the classes where they were used.

The second reason was that many of the teachers felt that it was inherently valuable to encourage pupils to take more responsibility for their own learning and Keller Plan was seen as one way of achieving that end.

WRITING THE KELLER PLAN UNITS— OUTLINE AND DISCUSSION

Outline

The main effort in starting a Keller Plan course is in writing the units and this section aims to give some guidance to teachers on how to produce a usable unit in a relatively short time, based on the experience of the seminar participants.

A unit is usually written in the form of a study guide, the purpose of which is to enable the pupil to use textbooks or other resources to reach the educational objectives defined by the teacher. Sometimes if the teacher feels that no suitable material can be found elsewhere, he writes the instructional material himself and includes it in the unit. In any event the unit must tell the pupil what the educational objectives are, tell him what to do to accomplish them and provide him with any extra helpful material which the teacher thinks is suitable. Whether the pupil reaches the objectives is determined by his performance in the unit test.

The following outline (adapted from one originally described by Ben A. Green, Jr.) was proposed at the seminar as a guide for writing a Keller Plan unit:

Introduction

This sets the unit into the context of the course as a whole, relates the unit to the pupil's prior experience and establishes its relevance to the pupil's progress. It should be interesting enough to motivate the pupil to start work on the unit.

Objectives

These describe precisely what the pupil is able to do as a result of work on the unit. They should be clear and specific so that the pupil can tell when he has accomplished each one. There should be enough of them to span the range of pupil performance expected.

Procedure

This tells the pupil what to do to accomplish all the objectives by giving him clear, detailed and specific instructions. If any material which is not related to the objectives is included in the procedure, it should be clearly

marked "optional". The procedure could involve directing the student to a number of activities such as reading a textbook, doing an experiment, viewing a film or slides, listening to a tape, tackling problems etc.

Test

The test should be consistent with the stated objectives and should cover all of them rather than sampling some of them. If a stated objective cannot be tested, it is not a valid objective. The test should be such that it can be completed by a knowledgeable pupil in no more than half an hour.

Two points are essential: firstly the objectives, procedure and test must be consistent; secondly, the procedure must be adequate to enable the pupil to achieve the objectives.

Beyond these necessities there is room for elegance and style. If the material is interesting or even amusing, pupils will work better on the course. A good unit should make it easy for the pupil to work hard.

Discussion

While the seminar participants agreed that the above outline was generally acceptable, there were differences of opinion on what constitutes an ideal unit and on how to produce it. A number of useful hints and pieces of advice emerged from the general discussion and are given below.

Preliminaries

It was felt that considerable preliminary planning is necessary before a teacher starts to write units. It is very helpful if the co-operation of other members of staff can be obtained both for writing units and running the course, since both exercises can be very time consuming. Teachers who write units should already be familiar with teaching the material in another mode.

Pupils should be given some guidance on working on their own before they tackle their first unit since for many, this will be a completely new experience.

Introduction

Many of the teachers had found it helpful to write the introduction to the unit last, once the unit topic, objectives, content and test had been decided.

Objectives

While all the participants agreed on the importance of objectives, there was variation in the way in which they were formulated and used. Many teachers found it more useful to identify the topic for a unit, determine the unit content and test, and then write the specific objectives rather than start with the objectives.

In many cases teachers found that the unit objectives only made sense to the pupils once they had completed the unit.

There was considerable variation in the precision with which objectives were stated. One teacher formulated very specific objectives in terms of pupil behaviour, the conditions under which the behaviour would be exhibited and a criterion of acceptable pupil performance. Another teacher was not convinced of the need to state objectives explicitly since he felt that his objectives were implied by the content of the unit and the test.

Pre-tests

Some of the teachers found it helpful to prepare a pre-test which the pupil would take before he was allowed to start a unit. The pre-test determined whether the pupil had the necessary pre-requisite knowledge to start on the unit.

Procedure

A number of important points were made during the seminar in connection with writing this part of the unit.

The teachers emphasised the importance of having available one or more good textbooks and a sufficient supply of them, around which to write a unit. It should be easy for the pupil to refer to any book, text, apparatus or other activity which is used in a unit so that he can quickly point out his difficulties to a teacher.

There was agreement that the layout and presentation of a unit are important and in this regard, it was thought to be helpful if the writer of a unit could use a typewriter. He could then control the layout and make changes to the unit as he was writing the first draft. It was felt that access to good typing and reprographic facilities was a decided advantage for unit writers.

A good unit was felt to be one which is self-explanatory, which the pupils like and which does not produce a queue of pupils with queries about the

instructions. If experiments are involved in a unit, they should be thoroughly tested in advance to ensure that they will work. In traditional teaching, the teacher can improvise and make necessary changes when demonstrating an experiment which he finds to be unsatisfactory for some reason. It is not easy for the teacher to do this when different pupils are doing different experiments in Keller Plan units.

If dangerous materials are to be handled in an experiment, safety procedures must be clearly written into the unit and appropriate steps taken to provide safety equipment.

There was agreement that while the length of a unit is determined by the content involved, short units are to be preferred to long ones. Pupils seem to work better with objectives which can be achieved fairly quickly, and they receive encouragement and motivation by completing a unit and passing the test. Most of the teachers had produced units which took the average pupil between one and three weeks to complete.

The time which it took teachers to write a unit was another subject of discussion. While there was variation among the teachers, it was felt that a reasonable estimate was that it would take 4–6 hours for an experienced writer to produce a unit which would occupy the average pupil for 6 or 7 periods. Teachers who are writing their first or second unit could expect to take considerably longer, until they had gained some experience. There was a danger in spending too long in adding refinements to a unit. Often these refinements turn out to be less useful than the writer thinks and the best revisions of a unit usually come from real use by pupils. Preliminary testing of units by use with a few pupils before more widespread use, is helpful if it can be arranged.

Finally, most teachers found that the written word predominated in their units, although media other than print were used where appropriate. While the unit writer must be careful regarding the layout of a unit and the language used in it, the teachers agreed that pupils with reading difficulties were at a disadvantage when using Keller Plan.

Test

Some teachers provided a number of parallel tests for each unit so that if a pupil failed one test, he could after further work be given a different but clearly similar test, to see if he had achieved the unit objectives. Other teachers provided only one test, part of which the pupil would resit if he failed it initially.

When a pupil failed a unit test, teachers would usually identify the pupil's weaknesses and help him over his difficulties until 100% mastery of the objectives was achieved. Because of the nature of some of the classes and the abilities of pupils in them, some teachers would drop the 100% mastery requirement for some pupils. The fact that 100% mastery of objectives is not required of pupils in external school examinations was a disincentive to teachers to demand it of all pupils in the Keller Plan units.

IMPLEMENTING KELLER PLAN

The previous section gave hints and advice on how one might write Keller Plan units. This section aims to describe some aspects of the pupils' use of the units written by the teachers who attended the seminar.

Many of the teachers found that complete self-pacing of a pupil's study in a subject using Keller Plan was restricted in practice. The existence of external and end of term examinations had led teachers to introduce target dates within their Keller Plan system. These target dates gave pupils a rough idea of the number of units they should have completed by that date, if they intended to complete in time all of the units covered by a particular examination. Teachers found that the target dates gave useful guidance to the pupils and also helped the teacher to identify those pupils who needed extra help.

It was found that rather than pupils working completely on their own on units, faster and slower groups would develop within a class, the membership of these groups changing from time to time. The teachers found that pupils would help each other within the groups and this was felt to be a useful feature of Keller Plan. For the fastest groups it was necessary for the teachers to produce extra units, sometimes with more practical work involved.

Another important aspect relating to self-pacing which was considered was whether all or only some of the staff of a school department were using Keller Plan. If the whole of a department were involved, a number of advantages accrued. There would be no difficulties in pupils, all at different stages in a Keller Plan course, being handed on from one teacher to another at the end of a year; temporary staff absences and staff changes due to promotion would not have a disastrous effect on a pupil's method of study; and a number of teachers could co-operate in writing units and providing tutorial help at any time. While it is quite possible for a teacher to introduce Keller Plan on his own, advantages are to be found if a whole department is involved.

There was general agreement that the teachers found that they had much more contact with individual pupils when using Keller Plan than they had before, and that this contact was much more useful to pupil and teacher alike. The teachers found that they became acquainted with their pupils and their problems very quickly. One or two teachers had found that when using Keller Plan there was not the same amount of general class discussion on a subject which they had before, and for this reason they introduced occasional lectures and discussion sessions.

There was discussion among the teachers on the number of pupils they could cope with in their Keller Plan courses. It was felt that a ratio of twenty pupils to one teacher was the maximum which would allow a course to run effectively and that a ratio of ten or fifteen pupils to one teacher would be ideal. If there were not careful preliminary planning and labelling and storing of equipment, there was a danger that the teacher might find himself increasingly involved in administrative work such as record-keeping, and in moving about laboratory equipment. Apart from careful planning of his course, the teacher could also decrease this danger by using technicians and laboratory assistants where available, for such non-teaching duties.

There was agreement that when using Keller Plan there was a change of emphasis in the teacher's role from instructor to tutor, motivator and manager and it had taken a few months for most of the teachers to adapt to their new role. It was felt that many teachers would see the abandonment of their traditional role as a threat to their control of the situation in their classroom. However, in all cases, the teachers found that if there had been any change at all, the discipline in their classes had improved and that damage to and loss of laboratory equipment had decreased since the introduction of Keller Plan. If the teacher can see his role in terms of enabling his pupils to learn rather than in terms of teaching them in a traditional manner, he should be able to adjust within a few months to the use of Keller Plan. In fact many teachers who had initially been against the introduction of the scheme had become converts to the idea within a short space of time.

On the question of the cost of introducing Keller Plan, all of the teachers had found that if one ignores the cost of the teacher's time in writing the units, Keller Plan courses did not cost any more to run than traditional courses. In fact since pupils in a Keller Plan are at different stages in their course at any one time, it was not always necessary to purchase full class sets of textbooks or pieces of laboratory equipment. However, such small savings had to be set against the greater use which was consequently

made of any piece of apparatus and the likelihood that it would have a shorter life. Certainly Keller Plan was found to be no more expensive than traditional teaching.

It had been found easier for pupils to locate and use apparatus involved in Keller Plan courses if there was a central store of laboratory equipment in the school. Some teachers had found it helpful to arrange the timetable so that all pupils in a year group taking a Keller Plan course in a subject could take that subject at the same time of the day, so that different teachers could tutor different groups across the year group. However, other teachers found that they could implement Keller Plan quite conveniently without this arrangement.

Finally, many teachers found that Keller Plan enabled them to identify the weak and poorly motivated pupils in a class much more quickly, and the scheme continued to make them aware of the problems of such pupils. The difficulties experienced with these pupils were, if anything, reduced by use of Keller Plan.

EVALUATION

The teachers present at the seminar had a general discussion on evaluation in relation to the use of Keller Plan in the classroom.

There was considerable variation in the evaluation strategies employed. One teacher evaluated his units in terms of the extent to which each unit's objectives had been achieved by pupils. Item analysis of test results by computer gave an indication of the effectiveness of each unit. In addition, he asked pupils to complete an attitude survey questionnaire at the end of each term. Other teachers asked pupils to complete a short feedback sheet at the end of each unit.

One teacher attempted to compare pupil performance in external and end of term examinations from one year to the next, where one group of pupils had used Keller Plan and one group had not. He had found small but statistically insignificant differences in marks in favour of the Keller Plan group, but he felt that there were a number of problems inherent in such comparisons which made the validity of the exercise doubtful. All of the teachers found that they could quickly determine where there were inadequacies in units by observing the pupils working and by receiving comments from them.

The teachers were in agreement on two important points. Firstly, for the teacher's own satisfaction and for the benefit of doubting colleagues, a

teacher implementing Keller Plan would have to provide evidence that the pupils were performing at least as well under a Keller Plan system in terms of examination marks as they had done under the traditional system.

Secondly, while the question of examination marks is one element of evaluation, any evaluation must be performed primarily with the interests of the pupils in mind. Thus the pupils' attitude to the system and observed progress while using the units should be of major importance in the evaluation of a Keller Plan course. The important question then becomes "Do the pupils like the units and do they appear to learn from them?" All of the teachers agreed that if they had not been able to answer that question honestly and satisfactorily when their courses were being used, they would have abandoned their schemes without hesitation. Another important point here is that while evaluation is an important aspect of any innovatory process, the pupils' interest must come first and they should not be unnecessarily burdened by filling in lengthy questionnaires and taking tests to attempt to prove the effectiveness of the system to outsiders.

Many of the teachers felt that ultimately evaluation is subjective and it depends to a large extent on an individual's standpoint and philosophy of education. In most of the schemes the teachers felt that they were not yet in a position to make definitive statements about the effectiveness of the units or pupil reaction to them.

A number of improvements had been made to the units as a result of feedback from pupils. In one school the need for target dates for completion of units and for a quiet room where pupils could work without noise, had been pointed out to teachers by the pupils. Thus formative evaluation was an integral aspect of the introduction of the Keller Plan courses.

The only conclusions which the teachers felt they were able to draw was that they were satisfied that their pupils' performance was at least as good under Keller Plan as it had been under the traditional system; and they felt that in general, the pupils enjoyed using the units and appeared to learn from them.

MODIFICATIONS TO THE KELLER PLAN

In Chapter 1 a summary was given of the five features which, according to Keller, set his plan apart from traditional teaching methods. From the teachers' papers in Chapter 2 and from the previous sections of this

chapter, the reader will have realised that when Keller Plan was used in the classroom, a number of modifications were made to Keller's original formulation. These modifications were discussed during the seminar and the discussion is summarised under the headings of the five features:

Self-pacing

The teachers had found that some degree of self-pacing was possible but it was restricted in practice because of the existence of external and end of term examinations.

Mastery

The teachers felt that the term "mastery" had to be clarified. If by mastery was meant achievement of all the unit's objectives, most of the teachers did not require mastery of their pupils. There were a number of reasons for this: teachers felt that some pupils in their classes were not capable of 100% mastery of objectives within the time constraints imposed by external and end of term examinations; 100% mastery of objectives is not required of pupils in examinations; and teachers felt that 100% mastery of certain important objectives was necessary while with other objectives, less than 100% mastery was acceptable. In connection with this latter reason, it was felt that mastery of some objectives was a necessary pre-requisite for future work, while other objectives were simply ends in themselves. In one scheme, mastery of some objectives in physics was not possible without some mathematical knowledge which pupils would acquire later in the year, so that it was not reasonable to require 100% mastery of pupils in that case.

Lectures as motivation

In practice the teachers found that lectures were infrequent, but in some Keller Plan schemes they were not optional and they did provide pupils with critical information. There was agreement that lectures could be very useful in motivating pupils and in widening their horizons beyond the syllabus covered in the units. Some teachers used lectures for revision purposes when all the pupils in a class had completed the unit connected with the lecture. Demonstration lectures were given when the teacher wished to perform an experiment which was too dangerous or costly for the pupils to perform individually.

The teachers felt that the lecture should be seen as one of a range of strategies to be adopted to enable pupils to learn and that a variation in the teacher's approach was helpful in maintaining pupils' interest. Many pupils came to regard lectures as something special because they were infrequent, and teachers noticed that pupils became much more attentive during lectures than they had previously been. Finally, some teachers felt that lectures had a value in reassuring the pupils that "the department had not stopped teaching them altogether". Pupils need time to develop confidence that they are learning from a new method of teaching and occasional lectures can help in giving them that confidence.

Stress upon the written word

The teachers did rely heavily upon the written word although films, tape/slide and other media had been used satisfactorily. Teachers found the written word faster, cheaper and more convenient to use than other media although they were happy to use any medium when they felt that it was appropriate and practical.

Use of proctors

None of the teachers had used pupils to mark tests. They felt that a qualified teacher was needed for this work.

CONCLUSIONS

The seminar concluded with discussion on how the work of the teachers present could be made more widely known. Although the experience of the seminar participants in using Keller Plan had been very encouraging, it was felt that there was a need for greater use of the Plan in schools in a number of subject areas before more definite conclusions could be drawn about its usefulness.

The teachers emphasised the importance for teachers wishing to implement Keller Plan of building on the work that has already been done and if possible, of visiting one or more of the schools where the Plan was being used.

It was felt that the Scottish Council for Educational Technology could help in this matter in two ways. Firstly, the publication of the booklet "Keller Plan in the Classroom" would help to make the present use of Keller Plan in schools more widely known. Secondly, it was expected that much valuable experience would be gained from the workshops on Keller

Plan which the Council planned to organise for groups of teachers later in the year. The workshops would be run with the help of teachers experienced in the use of Keller Plan and would introduce other teachers to the Plan, giving them practical experience in writing units and in running courses.

It will be clear to the reader from the case studies in Chapter 2 and from the previous sections of this chapter that the schemes being implemented by teachers in their classrooms cannot accurately be described as Keller Plan according to the description given in Chapter 1. The constraints imposed by the education system have led the teachers to modify the Plan in a number of ways.

However, all the schemes represent a radical departure from traditional methods of teaching and learning and the common ground among them is that the teachers involved were inspired by Keller's original idea and set out to implement his Plan in their own setting. It is for this reason that I feel it is appropriate to keep the title of the booklet as "Keller Plan in the Classroom".

FURTHER READING

The following list is not a comprehensive survey of all the work published on Keller Plan; the selection is intended to be a starting point for teachers who wish to learn more about this field. Much of the published work is American in origin and is concerned with the use of Keller Plan in higher education. The list includes some material which should be readily accessible to a British audience.

1. Keller, Fred S. "*Goodbye, Teacher...*". Journal of Applied Behavioural Analysis, Vol. 1, pp. 79–89, 1968.
2. Elton, L. R. B., Boud, D. J., Nuttall, J., Stace, B. S. *Teach Yourself Paradigm: the Keller Plan.* Chemistry in Britain, Vol. 9, No. 4, p. 164, 1973.
3. Green, Ben A., Jr. *Workshop on the Personalised System of Instruction, 1973.* Education Research Centre, M.I.T., Cambridge, Massachusetts 02139.
4. Keller, F. S., Sherman, J. G. *The Keller Plan Handbook, 1974.* W. A. Benjamin, Menlo Park, California, U.S.A.
5. Sherman, J. G. (Editor). *PSI 41 Germinal Papers. A Selection of Readings on the Keller Plan, 1974.* W. A. Benjamin, Menlo Park, California, U.S.A.
6. Boud, D. J., Bridge, W. A., Willoughby, L. *PSI now—a review of progress and problems.* British Journal of Educational Technology, Vol. 6, No. 2, pp. 15–34, 1975.
7. Special Issue on Individualisation in Higher Education. Programmed Learning and Educational Technology, Vol. 13, No. 1, 1976.
8. Friedman, C. P. *A Project to Individualise PSSC.* The Science Teacher, Vol. 43, No. 4, pp. 15–18, 1976.
9. Green, E. L. (Editor). *Towards Independent Learning in Science.* Hart-Davis Educational, 1976.
10. Self-Paced Study Bulletins. Institute for Educational Technology, University of Surrey. A series of bulletins published since 1974.